(19) Japan Patent and Trademark Office (JP)

(12) LAID OPEN [*KÔKAI*] PATENT GAZETTE (A)

(11) Patent Laid Open Application Publication No.: 2000-313690 (P2000-313690A)

(43) Date Laid Open: November 14, 2000

(51) Int. Cl^5	ID Symbol	F I	Subject Code (Ref.)
C30B 15/20		C30B 15/10	4G077
29/06	502	29/06 502A	

Inspection Request: Filed Number of Claims: 12 OL (Total 10 pages in original)

(21) Application No.: H11-120550

(22) Date Submitted: April 27, 1999

(71) Applicant: 000221122
Toshiba Ceramics Co. Ltd.
5-25 Nishi Shinjuku 7-chome
Shinjuku-ku, Tokyo, Japan

(72) Inventor: Junichi OSANAI
c/o Toshiba Ceramics Co. Ltd.
Hadano Research Center
30 Sôza, Rakuno-shi
Kanagawa-ken, Japan

(74) Agent: 100078765
Hisashi HATANO, Patent Attorney (and 1 other)

F Subjects (Ref.) 4G022, AA02, BA04, CF08, CF08, ED01, EG11

[*Translator's note: Addenda at the end of the Japanese document have been incorporated into the translated text.*]

(54) Patent Title: Semiconductor single crystal production method and solid semiconductor raw material ingot used therein

(57) [Abstract]

[Purpose] To provide a semiconductor single crystal production method and solid semiconductor raw material ingot used therein that supply the raw semiconductor ingot without contaminating the single crystal production apparatus, thereby improving the single crystallization yield without extending the cycle time required for a single pulling operation.

[Means of Solution] A semiconductor single crystal production method that possesses a process for affixing a solid raw semiconductor ingot M to a holding means S_2 that is provided on the seed crystal S, a process for melting

Location	Mode	Start	Time	Page	Result	Note
15097669123	NORMAL	6/ 8,16:50	1'31"	6	* O K	

crystal. The single crystal chamber was then closed and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the seed crystal and silicon polycrystal ingot were lowered into contact with the silicon melt remaining in the quartz crucible, completely melting the silicon polycrystal ingot.

[0058] The yield of the resulting dislocation-free silicon single crystal is shown in Table 1. In this comparison example, the gate valve was opened and closed once. After the part of the seed crystal corresponding with the holding means was then melted, a silicon single crystal was pulled by the usual method. The yield of the resulting dislocation-free silicon single crystal is shown in Table 2. In this condition of embodiment, the gate valve was closed and then opened only once.

[0062] <u>Comparison Example 2 (Recharging System)</u>

One silicon single crystal pulling operation was performed according to the usual method, using the pulling apparatus shown in Figure 9. The resulting single crystal was raised into the single crystal chamber and removed after closing the gate valve.

[0063] Next, a 50kg columnar silicon polycrystal ingot was installed using a special holding means in place of the single crystal that had been pulled. The single crystal chamber was then closed and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the silicon polycrystal ingot was lowered into contact with the silicon melt remaining in the quartz crucible, melting the silicon polycrystal ingot. The holding means was then raised into the single crystal chamber and the gate valve was closed to isolate it from the oven chamber, after which, the single crystal chamber was opened and the special holding means was replaced with a silicon seed crystal for single crystal pulling. The single crystal chamber was then closed, and after the internal atmosphere was brought to the same conditions as those of the oven chamber,

substantially the entire raw semiconductor ingot that is affixed to the holding means S_2 and accommodating same inside a vessel 6, and a process for growing a single crystal Ig by bringing the seed crystal S into contact with the raw semiconductor melt in the vessel 6.

[FIGURE]

- Legend -

1	Single crystal production apparatus
2	Oven component chamber
3	Single crystal container
4	Heater
6	Quartz crucible
10	Seed crystal holding means
M	Raw semiconductor ingot (silicon polycrystal ingot)
S	Seed crystal
S_2	Holding means (disk-shaped catch)

[Scope of the Patent Claim]

[Claim 1] A semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by bringing said seed crystal into contact with a raw semiconductor melt contained inside a vessel, wherein which semiconductor single crystal production method is characterized by possessing possesses a process for affixing a solid raw semiconductor ingot to a holding means that is provided on the seed crystal, a process for melting substantially the entire raw semiconductor ingot that is affixed to the holding means and accommodating same inside a vessel, and a process for growing a single crystal by bringing the seed crystal into contact with the raw semiconductor melt in the vessel.

[Claim 2] The semiconductor single crystal production method disclosed in Claim 1, which is characterized by possessing a process for having the semiconductor melt already placed inside the vessel, which process precedes the aforementioned process for melting substantially the entire raw semiconductor ingot that is affixed to the holding means.

[Claim 3] The semiconductor single crystal production method disclosed in Claim 2, which is characterized by the aforementioned process for having the

semiconductor melt already placed inside the vessel being a process in which raw semiconductor material is melted inside the vessel at the very start of semiconductor single crystal production.

[Claim 4] The semiconductor single crystal production method disclosed in Claim 2, which is characterized by the aforementioned process for having the semiconductor melt already placed inside the vessel being a process in which raw semiconductor melt from preceding semiconductor single crystal production is left inside the vessel.

[Claim 5] The semiconductor single crystal production method disclosed in any one of Claims 1 through 4, which is characterized by the aforementioned semiconductor single crystal production method being Czochralski's method.

[Claim 6] The semiconductor single crystal production method disclosed in any one of Claims 1 through 5, which is characterized by the solid semiconductor ingot being a silicon polycrystal and the seed crystal being a silicon single crystal.

[Claim 7] A solid raw semiconductor ingot that, in a raw semiconductor material used in the semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by Czochralski's method by bringing said seed crystal into contact with the raw semiconductor melt in a vessel, is characterized by the raw semiconductor ingot being held by a holding means that is provided on the aforementioned seed crystal.

[Claim 8] The solid raw semiconductor ingot disclosed in Claim 7, which is characterized by the aforementioned holding of the solid raw semiconductor ingot being accomplished by linking a catch provided in said raw semiconductor material to a holding means provided in the seed crystal.

[Claim 9] The solid raw semiconductor ingot disclosed in Claim 8, which is characterized by the aforementioned holding means provided in the seed crystal being a disk-shaped catch, and by the catch provided in the solid raw semiconductor ingot possessing a linkage groove into which the aforementioned seed crystal is fitted and a void into which the aforementioned disk-shaped catch on the seed crystal is fitted.

[Claim 10] The solid raw semiconductor ingot disclosed in Claim 8 or 9, which is characterized by the aforementioned seed crystal and solid raw semiconductor material both being column-shaped.

[Claim 11] The solid raw semiconductor ingot disclosed in Claim 10, which is characterized by the diameter of the aforementioned disk-shaped catch on the seed crystal being 3 to 4 times greater than the diameter of the column-shaped seed crystal.

[Claim 12] The solid raw semiconductor ingot disclosed in any one of Claims 7 through 11, which is characterized by the solid semiconductor ingot being a silicon polycrystal and the seed crystal being a silicon single crystal.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] This invention pertains to a semiconductor single crystal production method and the solid raw semiconductor ingot that is used therein, and more specifically pertains to a semiconductor single crystal production method and the solid raw semiconductor ingot that is used therein that provide for an improved raw semiconductor material supply method and improved single crystallization yield.

[0002]

[Prior Art] The semiconductor single crystal production method commonly used to manufacture semiconductor wafers is one in which a raw semiconductor polycrystal material is melted and a semiconductor single crystal is grown from a seed crystal by bringing said seed crystal, which is made from single crystal, into contact with said raw material melt.

[0003] For example, a method for producing silicon single crystal ingots by Czochralski's method (hereinafter, referred to as the CZ method) consists, as shown in Figure 10, of filling a quartz crucible 43, which is situated inside the oven component chamber 42 of a single crystal production apparatus 41, with silicon polycrystal raw material m_0 in the form of irregularly shaped chunks, and after then heating and completely melting the silicon polycrystal m_0 with a heater that is situated around the outside of the quartz crucible 43, dipping a seed crystal S_0 that is mounted on a seed chuck 45 into the

silicon melt and pulling the seed crystal S_0, while rotating the seed crystal S_0 and the quartz crucible 43, to grow a silicon single crystal Ig_0.

[0004] Since the raw silicon polycrystal material commonly used is in the form of irregularly shaped chunks, the chunks of silicon polycrystal m_0 that fill the quartz crucible 43 are heaped up, as shown in Figure 10, making it difficult to fill the quartz crucible with a large quantity at one time. In addition, an expensive new quartz crucible 42 must be used each time a single crystal is pulled, increasing the pulling cost.

[0005] Therefore, a so-called raw material replenishing system has been proposed as a measure to reduce costs. In this raw material replenishing system, a gate valve 52 can be used to separate the single crystal production apparatus 51 into the oven component chamber 53 and the single crystal chamber 54 when necessary, so that, with the gate valve open 52, the quartz crucible 55 situated inside the oven component chamber 53 is filled at the beginning of the single crystal pulling operation (Figure 11(a)), the silicon polycrystal chunks m_0 are melted to fill the quartz crucible 55 approximately 80% with silicon melt L_0 (Figure 11(b)), a solid, rod-shaped silicon polycrystal ingot M_0, which is raw material that is been prepared separately from the silicon melt L_0, is held by a silicon ingot holding means 56 and lowered into the silicon melt L_0 whereby it is melted and added to it (Figure 11(c)), causing the silicon melt L_0 to nearly entirely fill the quartz crucible 42.

[0006] On the other hand, after the silicon polycrystal ingot M_0 has been melted, the silicon ingot holding means 56 is raised, the gate valve 52 is completely closed, the silicon ingot holding means 56 is replaced with a seed crystal holding means 57 inside the single crystal chamber 54, which has now been isolated by the gate valve 52, and a seed crystal S is mounted in said seed crystal holding means 57 (Figure 11(d)).

[0007] After this, the gate valve 52 is opened and the seed crystal S_0 is brought into contact with the molten silicon melt L_0 in the quartz crucible 55 and a single crystal Ig_0 with the same crystal orientation as the seed crystal S_0 is grown on the bottom of the seed crystal S_0 (Figure 11(e)), whereby the

silicon melt L_0 inside the quartz crucible 55 is nearly depleted (Figure 11(e)).

[0008] With the semiconductor single crystal production method using the aforementioned single crystal production apparatus 51, the quantity of silicon single crystal produced per quartz crucible is increased over that of common CZ production methods, like that shown in Figure 11.

[0009] However, in this production method, the gate valve 52 must be closed at least once while the heater 58, etc. is on during operation of the single crystal production apparatus 51 to separate the oven component chamber 53 from the single crystal chamber 54. At this time the single crystal chamber 54 must be opened and the seed holding means 57 replaced with the silicon ingot apparatus 56, and then the silicon polycrystal ingot M_0 must be mounted on the silicon ingot holding means 56 or the seed crystal S_0 must be mounted on the seed crystal holding means 57, exposing the single crystal chamber 54 to the atmosphere. When the single crystal chamber 54 is reconnected to the oven component chamber 54 after being exposed to the atmosphere, dust drops down from the single crystal chamber 54, which hinders growth of the single crystal Ig_0 and is a major factor in decreased single crystal yields (the percentage of single crystal obtained without any crystal defects). Furthermore, dust, etc. is also dropped from the gate valve chamber 59 due to opening and closing of the gate valve 52.

[0010] A raw material recharging system, as shown in Figure 12, has also been proposed as a cost reducing measure.

[0011] In this recharging system, a gate valve 62 can be used to separate the single crystal production apparatus 61 into the oven component chamber 63 and the single crystal chamber 64 when necessary, so that, with the gate valve open 62, the single crystal Ig_1 is pulled up and removed, leaving molten silicon L_1 in the quartz crucible 65 situated in the oven component chamber 63 (Figure 12(a)), after which, inside the single crystal chamber 64, now isolated by the gate valve 62, the seed crystal holding means 66 is replaced with a silicon ingot holding means 67 (Figure 12(b)), a silicon polycrystal ingot M_1 is mounted on said silicon ingot holding means 67 and lowered into

the silicon melt L_1, whereby it is melted into the silicon melt L_1 (Figure 12(c)).

[0012] While the quartz crucible 65 is nearly entirely filled with the silicon melt L_1 by melting the silicon polycrystal ingot M_1, the silicon holding means 67, on which the silicon polycrystal ingot M_1 that it was holding is no longer present, is raised, the gate valve 62 is closed and, inside the single crystal chamber 64, now isolated by the gate valve 62, the silicon ingot holding means 67 is replaced with seed crystal holding means 66 and a seed crystal S_1 is mounted on said seed crystal holding means 66 (Figure 12(d)).

[0013] The gate valve 62 is then opened, the seed crystal S_1 is brought into contact with the molten silicon polycrystal M1 in the quartz crucible 65, and a single crystal Ig_1 is caused to grow on the seed crystal S_1 (Figure 12(e)).

[0014] However, in this production method, the gate valve 62 must be closed at least twice while the heater 68, etc. is on during operation of the single crystal production apparatus 61 to separate the oven component chamber 63 from the single crystal chamber 64. At this time the single crystal chamber 64 must be opened and the seed holding means 67 replaced with the silicon ingot apparatus 56, or conversely the silicon ingot apparatus 57 replaced with the seed holding means 67, twice exposing the single crystal chamber 64 to the atmosphere.

[0015] Consequently, the oven component chamber 63 is even further contaminated by dust, etc. in this recharging system than the replenishing system, which hinders growth of the single crystal Ig_0 and is a major factor in decreased single crystallization yields.

[0016] Furthermore, since gas must be replaced inside the pulling apparatus in both the replenishing and recharging systems described above, these also have the problem of requiring longer cycle times for a single pulling operation than the normal CZ method.

[0017]

[Problems to be Solved by the Invention] Therefore, there is a demand for a semiconductor single crystal production method and solid semiconductor raw material ingot used therein with which there is no contamination of the single crystal production apparatus when supplying the raw semiconductor material, thereby improving the single crystallization yield without extending the cycle time required for a single pulling operation.

[0018] Taking the circumstances described above into consideration, the purpose of this invention is to provide a semiconductor single crystal production method and solid semiconductor raw material ingot used therein that supply the raw semiconductor ingot without contaminating the single crystal production apparatus, thereby improving the single crystallization yield without extending the cycle time required for a single pulling operation.

[0019]

[Means of Solving the Problems] The gist of the invention of Claim 1 of this application, created to achieve the aforementioned purpose, is a semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by bringing said seed crystal into contact with a raw semiconductor melt contained inside a vessel, wherein which semiconductor single crystal production method is characterized by possessing possesses a process for affixing a solid raw semiconductor ingot to a holding means that is provided on the seed crystal, a process for melting substantially the entire raw semiconductor ingot that is affixed to the holding means and accommodating same inside a vessel, and a process for growing a single crystal by bringing the seed crystal into contact with the raw semiconductor melt in the vessel.

[0020] The gist of the invention of Claim 2 of this application is the semiconductor single crystal production method disclosed in Claim 1, which is characterized by possessing a process for having the semiconductor melt already placed inside the vessel, which process precedes the aforementioned process for melting substantially the entire raw semiconductor ingot that is affixed to the holding means.

[0021] The gist of the invention of Claim 3 of this application is the semiconductor single crystal production method disclosed in Claim 2, which is characterized by the aforementioned process for having the semiconductor melt already placed inside the vessel being a process in which raw semiconductor material is melted inside the vessel at the very start of semiconductor single crystal production.

[0022] The gist of the invention of Claim 4 of this application is the semiconductor single crystal production method disclosed in Claim 2, which is characterized by the aforementioned process for having the semiconductor melt already placed inside the vessel being a process in which raw semiconductor melt from preceding semiconductor single crystal production is left inside the vessel.

[0023] The gist of the invention of Claim 5 of this application is the semiconductor single crystal production method disclosed in any one of Claims 1 through 4, which is characterized by the aforementioned semiconductor single crystal production method being Czochralski's method.

[0024] The gist of the invention of Claim 6 of this application is the semiconductor single crystal production method disclosed in any one of Claims 1 through 5, which is characterized by the solid semiconductor ingot being a silicon polycrystal and the seed crystal being a silicon single crystal.

[0025] The gist of the invention of Claim 7 of this application is a solid raw semiconductor ingot that, in a raw semiconductor material used in the semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by Czochralski's method by bringing said seed crystal into contact with the raw semiconductor melt in a vessel, is characterized by the raw semiconductor ingot being held by a holding means that is provided on the aforementioned seed crystal.

[0026] The gist of the invention of Claim 8 of this application is the solid raw semiconductor ingot disclosed in Claim 7, which is characterized by the aforementioned holding of the solid raw semiconductor ingot being accomplished by linking a catch provided in said raw semiconductor material to a holding means provided in the seed crystal.

[0027] The gist of the invention of Claim 9 of this application is the solid raw semiconductor ingot disclosed in Claim 8, which is characterized by the aforementioned holding means provided in the seed crystal being a disk-shaped catch, and by the catch provided in the solid raw semiconductor ingot possessing a linkage groove into which the aforementioned seed crystal is fitted and a void into which the aforementioned disk-shaped catch on the seed crystal is fitted.

[0028] The gist of the invention of Claim 10 of this application is the solid raw semiconductor ingot disclosed in Claim 8 or 9, which is characterized by the aforementioned seed crystal and solid raw semiconductor material both being column-shaped.

[0029] The gist of the invention of Claim 11 of this application is the solid raw semiconductor ingot disclosed in Claim 10, which is characterized by the diameter of the aforementioned disk-shaped catch on the seed crystal being 3 to 4 times greater than the diameter of the column-shaped seed crystal.

[0030] The gist of the invention of Claim 12 of this application is the solid raw semiconductor ingot disclosed in any one of Claims 7 through 11, which is characterized by the solid semiconductor ingot being a silicon polycrystal and the seed crystal being a silicon single crystal.

[0031]

[Conditions of Embodiment of the Invention] A single crystal production apparatus that uses a so-called raw material replenishing system will be described below, based on the attached figures, as one condition of embodiment of the semiconductor single crystal production method associated with this invention.

[0032] As shown in Figure 1, the single crystal production apparatus that uses the semiconductor single crystal production method of this invention, e.g., a CZ method single crystal pulling apparatus 1, comprises an oven component chamber 2 and a single crystal chamber 3, which is situated above and linked to said oven component chamber 2. A vessel, e.g., a quartz crucible 6, which is built into a graphite crucible 5 and heated by a heater 4, is disposed inside the oven component chamber 2, and chunks of raw silicon

polycrystal m are heated and melted inside this quartz crucible 6. The graphite crucible 5 is mounted on a crucible rotation shaft 8, which passes through the oven body 7 and is linked to and driven by a motor (not shown).

[0033] In addition, a cylindrical seed holding means 10 is provided attached to the lower end of a wire 9, which is disposed so that it can be freely raised and lowered to and from the single crystal chamber 3, and a seed crystal S is mounted in this seed crystal holding means 10.

[0034] As shown enlarged in Figure 2 and Figure 3, the seed crystal S that is mounted in the seed crystal holding means 10 is formed of a seed crystal body S_1, which is shaped into a true column, and a holding means, e.g., a disk-shaped, circular catch S_2, which is disposed at one end of said seed crystal body S_1.

[0035] In addition, a solid semiconductor raw material ingot, e.g., a raw silicon polycrystal ingot with a solid, columnar form, is held on this seed crystal S, and a hollow void M_1, which accommodates the aforementioned circular catch S_2, a link M_2, which is connected to said void M1 and links with the circular catch S_2, and a link slot M_3, which is formed in said link M_2, are all disposed at one end, e.g., the upper end, of the silicon polycrystal ingot M.

[0036] Now, 11 is a link pin that passes through a mounting hole S_3 provided in the seed crystal S, and holds the seed crystal S to the seed crystal holding means 10.

[0037] It is preferable for the diameter d_1 of the aforementioned circular catch S_2 of the seed crystal S is 3 to 4 times the diameter d_2 of the seed crystal body S_1, and for the thickness t_1 of the circular catch S_2 to be 20mm or greater. It is also preferable for the thickness t_2 of the link M_2 also to be 20mm or greater and for the height h_1 of the void M_1 to be 50mm or greater.

[0038] Consequently, the silicon polycrystal M is held by the seed crystal S by linking the circular catch S_2 into the link M_2 so that it is accommodated in the void M_3 with the seed crystal body S_1 passing through the link slot M_3, as shown in Figure 4.

[0039] Next, the raw material replenishing system of the semiconductor single crystal production method of this invention will be described, using the single crystal pulling apparatus 1.

[0040] Figure 8 is a process drawing of a replenishment-type semiconductor single crystal production method, wherein the quartz crucible 6, which is situated inside the oven component chamber 2 of the single crystal pulling apparatus 1, is filled with chucks of raw silicon polycrystal m and a seed crystal S is mounted on the seed crystal holding means 10, which is attached to the end of the wire 9 in the single crystal chamber 3. The seed crystal body S_1 of the seed crystal S is then inserted into the link slot M_3 from the side of the link slot M_3, so that the circular catch S_2 is accommodated in the void M_3, linking the circular catch S_2 with the link M_2, whereby the silicon polycrystal ingot M is suspended from and attached to the wire 9 by means of the seed crystal S and the seed crystal holding means 10 (Figure 8(a)).

[0041] Next, the heater 4, which is disposed around the outside of the quartz crucible 6, is turned on to heat and completely melt the chunks of silicon polycrystal m, filling the quartz crucible 6 approximately 80% with the silicon melt L prior to melting the silicon polycrystal ingot M (Figure 8(b)). Furthermore, the silicon polycrystal ingot M, which was prepared separately from the chunks of silicon polycrystal m and is support by the circular catch S_2 of the seed crystal S that was already placed inside the single crystal void 3, is lowered and melted into the silicon melt L (Figure 8(c)). When the silicon polycrystal ingot M is melted, the silicon melt L nearly entirely fills the quartz crucible 6.

[0042] Meanwhile, the silicon polycrystal ingot M is melted, entirely exposing the seed crystal S and placing it in a state in which it can serve the function as the seed crystal for pulling (Figure 8(d)). Now, in the event that the link M_2 of the silicon polycrystal ingot M remains unmelted on top of the circular catch S_2, the rate of rotation of the seed crystal S can be increased to cause the link M_2 to drop into the silicon melt L by centrifugal force. Additionally, if silicon polycrystal ingot M is essentially entirely

melted, exposing the circular catch S_2 of the seed crystal S, the unmelted portion of the silicon polycrystal ingot M can be left as it is attached to the seed crystal.

[0043] The interior of the single crystal pulling apparatus 1 is then brought to the single crystal pulling conditions, the circular catch S_2 of the seed crystal S is brought into contact with the molten silicon melt L inside the quartz crucible 6, and, once the circular catch S_2 has melted, the single crystal Ig is grown on the seed crystal S (Figure 8(e)).

[0044] Furthermore, when growing and pulling of the single crystal ingot Ig is completed, there will be no re-useable molten silicon L remaining in the quartz crucible 6 (Figure 8(e)).

[0045] By using the seed crystal S as the basic seed crystal and as a holding means to support the silicon polycrystal ingot M according to the semiconductor single crystal production method of this invention described above, the silicon polycrystal ingot M can be melted as replenishment raw material without needing to open the oven 8 or the single crystal chamber 3 to replace the seed crystal holding means 10 with a silicon ingot holding means. Consequently, it becomes possible to supply enough silicon melt L without contaminating the quartz crucible 6, whereby a large capacity silicon single crystal Ig can be pulled at one time with high single crystallization yield.

[0046] It also becomes unnecessary to selectively separate the single crystal pulling apparatus 1 into an oven component chamber 2 and a single crystal chamber 3 by means of a gate valve, so that the molten silicon melt L is not contaminated by dust, etc. dropping from the single crystal chamber 3 as the gate valve is opened and closed, which in turn allows the single crystallization yield to be increased since there is no hindrance to the growth of the single crystal.

[0047] Furthermore, since there is no need to open the oven 7 or the single crystal chamber 3 during the series of processes, except when simultaneously installing the chunks of silicon polycrystal m and the silicon polycrystal ingot M at the beginning of the pulling process, and when removing the single crystal ingot Ig that has been pulled, gas replacement also becomes

unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method.

[0048] Next, the so-called raw material recharging system, which is another condition of embodiment of the semiconductor single crystal production method of this invention, will be described, using the single crystal pulling apparatus 1 described above.

[0049] Figure 9 is a process drawing of a recharge-type semiconductor single crystal production method, wherein the single crystal Ig being pulled is pulled and molten silicon L is left in the quartz crucible 6 (Figure 9(a)), after which, the gate valve is closed and the single crystal Ig is removed, while a seed crystal S with the same structure as that shown in Figure 8 and used in the condition of embodiment described above is mounted in the seed crystal holding means 10, and the circular catch S_2 of said seed crystal S is linked into the void M_1 in the silicon polycrystal ingot M (Figure 9(b)). The silicon polycrystal ingot M is then lowered and melted into the silicon melt L already in the quartz crucible 6 (Figure 9(c)). When the silicon polycrystal ingot M is melted, the silicon melt L nearly entirely fills the quartz crucible 6.

[0050] Meanwhile, the silicon polycrystal ingot M is melted, entirely exposing the seed crystal S and placing it in a state in which it can serve the function as the seed crystal for pulling (Figure 9(d)). The interior of the single crystal pulling apparatus 1 is then brought to the single crystal pulling conditions, the circular catch S_2 of the seed crystal S is brought into contact with the molten silicon melt L inside the quartz crucible 6, and, once the circular catch S_2 has melted, the single crystal Ig is grown on the seed crystal S (Figure 9(e)).

[0051] By using the seed crystal S as the basic seed crystal and as a holding means to support the silicon polycrystal ingot M according to the semiconductor single crystal production method of this invention described above, it is necessary to open the single crystal chamber 3 only once to replace the seed crystal holding means 10 and the silicon ingot holding means. Consequently, it becomes possible to pull the silicon single crystal Ig with

good single crystallization yield, which contributes to lower the costs of producing semiconductor single crystals.

[0052] Thus, it becomes possible to supply enough silicon melt while decreasing the number of times that the gate valve is opened and closed, which was at least twice in the past recharging method, and decreasing the chances for contamination inside the oven accompanying said opening and closing, making it possible to pull silicon single crystals with high single crystallization yield.

[0053]

[Example Embodiment] Example Embodiment 1 (Replenishment System)

Using the pulling apparatus shown in Figure 8, with the oven chamber 2 and single crystal chamber 3 open to the atmosphere, a 22-inch diameter quartz crucible was filled with 100kg of silicon polycrystal chunks. A seed crystal equipped with the holding means of this invention was then placed in the single crystal chamber 3 in this state and a 20kg columnar silicon polycrystal ingot was suspended on said seed crystal. Then, the oven chamber and single crystal chamber were closed with the gate valve in the open state.

[0054] Next, after melting the silicon polycrystal inside the quartz crucible, the silicon polycrystal held by the seed crystal was lowered, brought into contact with the silicon melt in the quartz crucible and completely melted. The seed crystal was then brought into contact with the silicon melt, melting the part corresponding with the holding means, after which, a silicon single crystal was pulled by the usual method. The yield of the resulting dislocation-free silicon single crystal is shown in Table 1. In this condition of embodiment, there was no opening or closing of the gate valve.

[0055] Comparison Example 1 (Replenishment System)

Using the pulling apparatus shown in Figure 8, with the oven chamber 2 and single crystal chamber 3 open to the atmosphere, a 22-inch diameter quartz crucible was filled with 100kg of silicon polycrystal chunks. A columnar silicon polycrystal ingot was then suspended in the single crystal chamber 3

in this state by means of a special holding means, and the oven chamber and single crystal chamber were closed with the gate valve in the open state.

[0056] Next, after melting the silicon polycrystal inside the quartz crucible, the silicon polycrystal held by the special holding means was lowered, brought into contact with the silicon melt in the quartz crucible and melted.

[0057] The holding means was then raised into the single crystal chamber and the gate valve was closed to isolate it from the oven chamber, after which, the single crystal chamber was opened and the special holding means was replaced with a silicon seed crystal for single crystal pulling. The single crystal chamber was then closed, and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the seed crystal was lowered, and a silicon single crystal was pulled according to the usual method.

[0058] The yield of the resulting dislocation-free silicon single crystal is shown in Table 1. In this comparison example, the gate valve was closed and then opened once.

[0059]

[Table 1]

	Example Embodiment 1	Comparison Example 1
Dislocation-free Single Crystal Yield	1.18	1

Note 1: Ratio where the yield of the dislocation-free single crystal in the Comparison Example 1 is set to 1.

Note 2: These figures reflect the average values obtained by 10 pulling operations for each Example Embodiment 1 and Comparison Example 1

[0060] <u>Example Embodiment 2 (Recharging System)</u>

One silicon single crystal pulling operation was performed according to the usual method, using the pulling apparatus shown in Figure 9. The resulting single crystal was raised into the single crystal chamber and removed after closing the gate valve.

[0061] Next, a seed crystal equipped with the holding means of this invention was installed in place of the single crystal that had been pulled and a 50kg columnar silicon polycrystal ingot was suspended on said seed

crystal. The single crystal chamber was then closed and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the seed crystal and silicon polycrystal ingot were lowered into contact with the silicon melt remaining in the quartz crucible, completely melting the silicon polycrystal ingot.

[0058] The yield of the resulting dislocation-free silicon single crystal is shown in Table 1. In this comparison example, the gate valve was opened and closed once. After the part of the seed crystal corresponding with the holding means was then melted, a silicon single crystal was pulled by the usual method. The yield of the resulting dislocation-free silicon single crystal is shown in Table 2. In this condition of embodiment, the gate valve was closed and then opened only once.

[0062] Comparison Example 2 (Recharging System)

One silicon single crystal pulling operation was performed according to the usual method, using the pulling apparatus shown in Figure 9. The resulting single crystal was raised into the single crystal chamber and removed after closing the gate valve.

[0063] Next, a 50kg columnar silicon polycrystal ingot was installed using a special holding means in place of the single crystal that had been pulled. The single crystal chamber was then closed and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the silicon polycrystal ingot was lowered into contact with the silicon melt remaining in the quartz crucible, melting the silicon polycrystal ingot. The holding means was then raised into the single crystal chamber and the gate valve was closed to isolate it from the oven chamber, after which, the single crystal chamber was opened and the special holding means was replaced with a silicon seed crystal for single crystal pulling. The single crystal chamber was then closed, and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the seed crystal was lowered, and a silicon single crystal was pulled according to the usual method.

[0064] The yield of the resulting dislocation-free silicon single crystal is shown in Table 2. In this example, the gate valve was closed and then opened twice.

[0065]

[Table 2]

	Example Embodiment 2	Comparison Example 2
Dislocation-free Single Crystal Yield	1.05	1

Note 1: Ratio where the yield of the dislocation-free single crystal in the Comparison Example 1 is set to 1.

Note 2: These figures reflect the average values obtained by 10 pulling operations for each Example Embodiment 2 and Comparison Example 2

[0066]

[Effect] By using the seed crystal as both a seed crystal and as a holding means whereby the solid raw semiconductor ingot is suspended, according to the semiconductor single crystal production method of this invention, swapping of said holding means is eliminated, making it possible to prevent contamination of the inside of the single crystal production apparatus and the silicon melt that accompanies the supply of raw material by means of a solid semiconductor ingot, and to provide for improved single crystallization yield.

[0067] In addition, this combined use of the seed crystal makes it possible to supply enough silicon melt to the quartz crucible using solid raw semiconductor ingots as raw replenishment material while entirely eliminating exposure the oven or any part thereof, or at least decreasing the number of times it is exposed, and since it further becomes unnecessary to replace the gas inside the oven, there is no extension of the cycle time required for each pulling.

[0068] Furthermore, since the enough uncontaminated silicon melt can be supplied to the quartz crucible when the raw material replenishment system is used, large capacity silicon single crystals can be pulled with high single crystallization yield.

[0069] Additionally, since uncontaminated silicon melt can be repeatedly supplied to the quartz crucible when the raw material recharging system is used, the number of silicon single crystals that can be pulled from a single

quartz crucible with high single crystallization yield can be increased, allowing for decreased production costs.

[0070] Furthermore, since the solid semiconductor raw material ingot can be suspended by linking a link disposed in said raw semiconductor ingot with a holding means disposed in the seed crystal, it becomes possible to use the seed crystal as both a seed crystal and as the holding means whereby the solid semiconductor raw material ingot is suspended, which eliminates the need to replace the holding means, prevents contamination of the raw semiconductor melt that accompanies the supply of raw material by means of a solid raw semiconductor ingot, and allows for increased single crystallization yields. In addition, it becomes unnecessary to replace the gas inside the oven and there is no extension of the cycle time required per single pulling.

[0071] It is further possible to pull high-crystallization yield semiconductor single crystals when the catch disposed on the seed crystal is shaped like a disk.

[0072] Additionally, when the diameter of the circular catch on the seed crystal is 3 to 4 times larger than the diameter of the columnar seed crystal, it is possible to securely hold the solid semiconductor raw material ingot and to pull high-crystallization yield semiconductor single crystals.

[Brief Explanation of the Figures]

[Figure 1] This is a conceptual drawing of the single crystal production apparatus used in the semiconductor single crystal production method of this invention.

[Figure 2] This is a side-view drawing of the seed crystal that is incorporated into the single crystal production apparatus used in the semiconductor single crystal production method of this invention.

[Figure 3] This is a plan-view drawing of the seed crystal shown in Figure 2.

[Figure 4] This is an explanatory drawing showing the condition of linkage between the semiconductor raw material ingot and the seed crystal that is incorporated into the single crystal production apparatus used in the semiconductor single crystal production method of this invention.

[Figure 5] This is a plan-view drawing of the semiconductor raw material ingot shown in Figure 4.

[Figure 6] This is a side-view drawing of the semiconductor raw material ingot shown in Figure 4.

[Figure 7] This is a sectional drawing of the semiconductor raw material ingot shown in Figure 4.

[Figure 8] This is a process drawing of the production process that is one condition of embodiment of the semiconductor single crystal production method of this invention.

[Figure 9] This is a process drawing of the production process that is another condition of embodiment of the semiconductor single crystal production method of this invention.

[Figure 10] This is a conceptual drawing of the single crystal production apparatus used in a past semiconductor single crystal production method.

[Figure 11] This is a process drawing of the production process of a past semiconductor single crystal production method.

[Figure 12] This is a process drawing of the production process of another past semiconductor single crystal production method.

[Legend]

1	single crystal production apparatus
2	oven component chamber
3	single crystal chamber
4	heater
5	graphite crucible
6	quartz crucible
7	oven
8	crucible rotation shaft
9	wire
10	seed crystal holding means
11	link pin
M	semiconductor raw material ingot (silicon polycrystal ingot)
M_1	void

M_2 link

M_3 link slot

S seed crystal

S_1 seed crystal body

S_2 seed holding means (circular catch)

S_3 mounting hole

[Fig. 3] [Fig. 5] [Fig. 6] [Fig. 7]

[FIGURES]

[Fig. 1] [Fig. 2] [Fig. 4]

[FIGURES]

-Legend-
1 single crystal production apparatus
2 oven component chamber
3 single crystal chamber
4 heater
6 quartz crucible
10 seed crystal holding means
M semiconductor raw material ingot (silicon polycrystal ingot)
S seed crystal
S_2 seed holding means (circular catch)

[Fig. 9]

[FIGURES (a)-(e)]

[Fig. 8]

[FIGURES (a)-(f)]

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（A）　(11)特許出願公開番号
特開2000－313690
（P2000－313690A）
(43)公開日　平成12年11月14日(2000.11.14)

(51)Int.Cl.⁷	識別記号	F I	テーマコード(参考)
C30B　15/02		C30B　15/02	4G077
29/06	502	29/06　　502A	

審査請求　未請求　請求項の数12　ＯＬ　（全 10 頁）

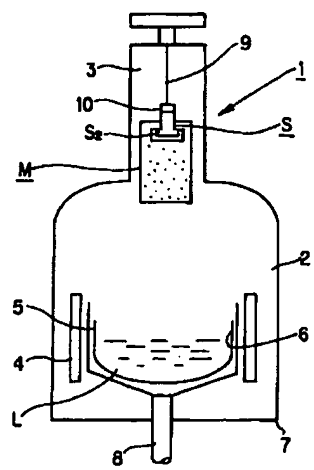
(21)出願番号　特願平11－120550
(22)出願日　平成11年4月27日(1999.4.27)

(71)出願人　000221122
東芝セラミックス株式会社
東京都新宿区西新宿七丁目５番25号
(72)発明者　小山内　淳一
神奈川県秦野市曽屋30番地　東芝セラミックス株式会社開発研究所内
(74)代理人　100078765
弁理士　波多野　久　（外１名）

Ｆターム(参考)　4G077 AA02 BA04 CF06 CF08 ED01 EG11

(54)【発明の名称】　半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊

(57)【要約】
【課題】単結晶製造装置を汚染することなく半導体原料塊の供給が行えて、単結晶化率も向上し、かつ１回の引上げに要するサイクルタイムを長くすることのない半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊を提供する。
【解決手段】種結晶Ｓに設けた保持手段Ｓ２に固体の半導体原料塊Ｍを保持させる工程と、保持手段Ｓ２に保持された半導体原料塊の実質的に全部を溶融して容器６内に収容させる工程と、容器６内の半導体原料融液Ｌに種結晶Ｓを接触させて単結晶Ｉｇを成長させる半導体単結晶の製造方法。



1　単結晶製造装置
2　炉部材収納室
3　単結晶収納部
4　ヒータ
6　石英ルツボ
10　種結晶保持手段
M　半導体原料塊(多結晶シリコン塊)
S　種結晶
S_2　保持手段(円形係止部)

【特許請求の範囲】

【請求項１】　容器内に収容された半導体原料融液に種結晶を接触させて種結晶から半導体単結晶を成長させる半導体単結晶の製造方法において、種結晶に設けられた保持手段に固体状態の半導体原料塊を保持させる工程と、前記保持手段に保持された前記半導体原料塊を溶融して前記容器内に収容させる工程と、前記容器内の半導体原料融液に前記種結晶を接触させて単結晶を成長させる工程とを有することを特徴とする半導体単結晶の製造方法。

【請求項２】　上記保持手段に保持された半導体原料塊を溶融する工程に先行する前工程として、予め容器内に半導体融液を収容させておく工程を有することを特徴とする請求項１に記載の半導体単結晶の製造方法。

【請求項３】　上記予め容器内に半導体融液を収容させておく工程は、半導体単結晶の製造の初期に容器内に半導体原料を溶融させる工程であることを特徴とする請求項２に記載の半導体単結晶の製造方法。

【請求項４】　上記予め容器内に半導体融液を収容させておく工程は、先行して行われる半導体単結晶の製造において半導体原料融液を残存させておく工程であることを特徴とする請求項２に記載の半導体単結晶の製造方法。

【請求項５】　上記半導体単結晶の製造方法はチョクラルスキー法であることを特徴とする請求項１ないし４のいずれか１項に記載の半導体単結晶の製造方法。

【請求項６】　固体の半導体原料塊は多結晶シリコンであり、種結晶は単結晶シリコンであることを特徴とする請求項１ないし５のいずれか１項に記載の半導体単結晶の製造方法。

【請求項７】　容器内に収容された半導体原料融液に種結晶を接触させて種結晶から半導体単結晶を成長させるチョクラルスキー法による半導体単結晶の製造方法に用いられる半導体原料において、前記種結晶に設けた保持手段により半導体原料塊が保持されたことを特徴とする固体の半導体原料塊。

【請求項８】　上記固体の半導体原料の保持は、この半導体原料に設けられた係止部と種結晶に設けられた保持手段とを係合させることにより行われることを特徴とする請求項７に記載の固体の半導体原料塊。

【請求項９】　上記種結晶に設けられた保持手段は円板形状の係止部であり、固体の半導体原料塊に設けられた係止部は前記種結晶が収納される係合溝部と前記種結晶の円形形状の係合部を収納する中空部とを有することを特徴とする請求項８に記載の固体の半導体原料塊。

【請求項１０】　上記種結晶および固体の半導体原料は円柱形状であることを特徴とする請求項８または９に記載の固体の半導体原料塊。

【請求項１１】　上記種結晶の円形形状の係止部の直径は、円柱形状の種結晶の直径の３ないし４倍であることを特徴とする請求項１０に記載の固体の半導体原料塊。

【請求項１２】　固体の半導体原料塊は多結晶シリコンであり、種結晶は単結晶シリコンであることを特徴とする請求項７ないし１１のいずれか１項に記載の固体の半導体原料塊。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊に係わり、特に半導体原料の供給方法を改善し単結晶化率の向上を図った半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊に関する。

【０００２】

【従来の技術】一般に半導体ウェーハの製造方法は、多結晶半導体原料を溶融し、この原料融液に単結晶よりなる種結晶を接触させ、種結晶から半導体単結晶を成長させる半導単結晶の製造方法が用いられている。

【０００３】例えば、チョクラルスキー法（以下、ＣＺ法という。）によるインゴット状のシリコン単結晶の製造方法は、図１０に示されるように、単結晶製造装置４１の炉部材収納室４２内に設置された石英ルツボ４３に不定形な小塊形状の原料の多結晶シリコンm0を充填し、石英ルツボ４３の外周に設けられたヒータ４４によって多結晶シリコンm0を完全に加熱溶融した後、シードチャック４５に取り付けられた種結晶（シード結晶）S0をシリコン融液に浸し、種結晶S0と石英ルツボ４３を逆方向に回転させ種結晶S0を引上げてシリコン単結晶Ｉｇ0を成長させるものである。

【０００４】一般に使用される原料の多結晶シリコンは不定形な小塊形状であるため、図１０に示すように、石英ルツボ４３に充填される小塊形状の多結晶シリコンm0は嵩張り、石英ルツボ４３に一度に大量に充填することは難しい。また、一回の単結晶引上げ毎に高価な新品の石英ルツボ４２を使用せねば成らず、引上げコストが上昇する。

【０００５】そこでコスト低減の方策として、図１１に示すようないわゆる原料追加チャージ方式が提案されている。この追加チャージ方式は単結晶製造装置５１をゲートバルブ５２により炉部材収納室５３と単結晶収納部５４に適宜仕切り可能にし、ゲートバルブ５２の開放状態で単結晶引上げ初期に炉部材収納室５３に配置された石英ルツボ５５に充填し（図１１（ａ））、小塊形状の多結晶シリコンm0を溶融して石英ルツボ５５の約８０％程度までシリコン融液L0を満たし（図１１（ｂ））、このシリコン融液L0とは別個に用意された原料で固体棒状の多結晶シリコン塊M0をシリコン塊保持手段５６により保持して降下させて、シリコン融液L0に接触させて追加溶融させ（図１１（ｃ））、シリコン融液L0が石英ルツボ４２のほぼ全体に満される。

【０００６】一方、多結晶シリコン塊M0の溶融後、シ

リコン塊保持手段５６を上昇させ、完全ゲートバルブ５２を閉じ、ゲートバルブ５２により仕切られた単結晶収納部５４内でシリコン塊保持手段５６と種結晶保持手段５７とを交換して取り付けし、この種結晶保持手段５７に種結晶Ｓが取り付けられる（図１１（ｄ））。

【０００７】しかる後、ゲートバルブ５２を開放し、種結晶S0を石英ルツボ５５中で溶融状態のシリコン融液L0に接触させて、種結晶S0の下部に種結晶S0と同じ結晶方位を有する単結晶Ｉｇ0を成長させ（図１１（ｅ））、石英ルツボ５５中にはシリコン融液L0がほとんど残らない状態とする（図１１（ｅ））。

【０００８】上記の単結晶製造装置５１を用いた半導体単結晶の製造方法によれば、図１１に示すような通常のＣＺ法の製造方法よりも石英ルツボ１個当たりのシリコン単結晶の生産量は増大する。

【０００９】しかし、この製造方法では、ヒータ５８等が付勢された状態で単結晶製造装置５１の稼働中に最低でも１回はゲートバルブ５２を閉じて、炉部材収納室５３と単結晶収納部５４とを分離し、かつこの単結晶収納部５４を開放してシリコン塊装置５６と種結晶保持手段５７との取付けの交換を行い、さらにシリコン塊保持手段５６への多結晶シリコン塊M0の取り付け、および種結晶保持手段５７への種結晶S0の取り付けを行わなければならず、単結晶収納部５４は大気に曝される。大気に曝された単結晶収納部５４を再度炉部材収納室５３と連通させると、単結晶収納部５４から塵埃などが落下し、単結晶Ｉｇ0の成長を阻害し単結晶化率（結晶欠陥が発生せず単結晶が得られる割合）を低減させる大きな要因になっている。さらに、ゲートバルブ５２の開閉によるゲートバルブ室５９からの塵埃などの落下も生じる。

【００１０】また、別のコスト低減の方策として、図１２に示すようなわゆる原料のリチャージ方式がある。

【００１１】このリチャージ方式は単結晶製造装置６１をゲートバルブ６２により炉部材収納室６３と単結晶収納部６４に適宜仕切り可能にし、ゲートバルブ６２の開放状態で単結晶Ｉｇ１を引上げて取り出し、炉部材収納室６３に配置された石英ルツボ６５に溶融シリコンＬ１を残存させ（図１２（ａ））、次に、ゲートバルブ６２により仕切られた単結晶収納部６４内で種結晶保持手段６６をシリコン塊保持手段６７に交換して取り付け（図１２（ｂ））、このシリコン塊保持手段６７に多結晶シリコン塊Ｍ１を取り付け、降下させてシリコン融液Ｌ１に接触させ溶融し、シリコン融液Ｌ１にする（図１２（ｃ））。

【００１２】多結晶シリコン塊Ｍ１の溶融によりシリコン融液Ｌ１は石英ルツボ６５のほぼ全体に満され、一方、保持する多結晶シリコン塊Ｍ１が存在しなくなったシリコン保持手段６７を上昇させ、ゲートバルブ６２を閉じ、ゲートバルブ６２により仕切られた単結晶収納部６４内でシリコン塊保持手段６７と種結晶保持手段６６とを交換して取り付け、この種結晶保持手段６６に種結晶Ｓ１が取り付けられる（図１２（ｄ））。

【００１３】しかる後、ゲートバルブ６２を開放し、種結晶Ｓ１を石英ルツボ６５中で溶融状態の多結晶シリコンＭ１に接触させて、種結晶Ｓ１に単結晶Ｉｇ１を成長させる（図１２（ｅ））。

【００１４】しかし、この製造方法でも、ヒータ６８等が付勢された状態で単結晶製造装置６１の稼働中に２回はゲートバルブ６２を閉じて、炉部材収納室６３と単結晶収納部６４とを分離し、かつこの単結晶収納部６４を開放して、種結晶保持手段６６とシリコン塊保持手段６７の交換、および逆にシリコン塊保持手段６７と種結晶保持手段６６の交換を行う必要があるため、単結晶収納部６４は２回も大気に曝される。

【００１５】従って、このリチャージ方式は追加チャージ方式に比べてさらに塵埃などの落下により炉部材収納室６３を汚損し、単結晶Ｉｇ0の成長を阻害し単結晶化率を低減させる大きな要因となる虞があった。

【００１６】さらに、上述した追加チャージ方式、リチャージ方式とも引上げ装置内のガス置換を必要とするため、１回の引上げに要するサイクルタイムは通常のＣＺ法よりも長くなる問題点がある。

【００１７】

【発明が解決しょうとする課題】そこで、原料半導体の供給時、半導体単結晶製造装置内を汚染することがなく、単結晶化率の向上が図れ、かつ１回の引上げに要するサイクルタイムも長くならない半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊が要望されていた。

【００１８】本発明は上述した事情を考慮してなされたもので、半導体単結晶製造装置を汚染することなく原料半導体供給が行えて、単結晶化率も向上し、かつ１回の引上げに要するサイクルタイムを長くすることのない半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊を提供することを目的とする。

【００１９】

【課題を解決するための手段】上記目的を達成するためになされた本願請求項１の発明は、容器内に収容された半導体原料融液に種結晶を接触させて種結晶から半導体単結晶を成長させる半導体単結晶の製造方法において、種結晶に設けられた保持手段に固体状態の半導体原料塊を保持させる工程と、前記保持手段に保持された前記半導体原料塊を溶融して前記容器内に収容させる工程と、前記容器内の半導体原料融液に前記種結晶を接触させて単結晶を成長させる工程とを有することを特徴とする半導体単結晶の製造方法であることを要旨としている。

【００２０】本願請求項２の発明では、上記保持手段に保持された半導体原料塊を溶融する工程に先行する前工程として、予め容器内に半導体融液を収容させておく工

程を有することを特徴とする請求項１に記載の半導体単結晶の製造方法であることを要旨としている。

【００２１】本願請求項３の発明では、上記予め容器内に半導体融液を収容させておく工程は、半導体単結晶の製造の初期に容器内に半導体原料を溶融させる工程であることを特徴とする請求項２に記載の半導体単結晶の製造方法であることを要旨としている。

【００２２】本願請求項４の発明では、上記予め容器内に半導体融液を収容させておく工程は、先行して行われる半導体単結晶の製造において半導体原料融液を残存させておく工程であることを特徴とする請求項２に記載の半導体単結晶の製造方法であることを要旨としている。

【００２３】本願請求項５の発明では、上記半導体単結晶の製造方法はチョクラルスキー法であることを特徴とする請求項１ないし４のいずれか１項に記載の半導体単結晶の製造方法であることを要旨としている。

【００２４】本願請求項６の発明では、固体の半導体原料塊は多結晶シリコンであり、種結晶は単結晶シリコンであることを特徴とする請求項１ないし５のいずれか１項に記載の半導体単結晶の製造方法。

【００２５】本願請求項７の発明では、容器内に収容された半導体原料融液に種結晶を接触させて種結晶から半導体単結晶を成長させるチョクラルスキー法による半導体単結晶の製造方法に用いられる半導体原料において、前記種結晶に設けた保持手段により半導体原料塊が保持されたことを特徴とする固体の半導体原料塊であることを要旨としている。

【００２６】本願請求項８の発明では、上記固体の半導体原料の保持は、この半導体原料に設けられた係止部と種結晶に設けられた保持手段とを係合させることにより行われることを特徴とする請求項７に記載の固体の半導体原料塊であることを要旨としている。

【００２７】本願請求項９の発明では、上記種結晶に設けられた保持手段は円板形状の係止部であり、固体の半導体原料塊に設けた係止部は前記種結晶が収納される係合溝部と前記種結晶の円形形状の係合部を収納する中空部とを有することを特徴とする請求項８に記載の固体の半導体原料であることを要旨としている。

【００２８】本願請求項１０の発明では、上記種結晶および固体の半導体原料は円柱形状であることを特徴とする請求項８または９に記載の固体の半導体原料塊であることを要旨としている。

【００２９】本願請求項１１の発明では、上記種結晶の円形形状の係止部の直径は、円柱形状の種結晶の直径の３ないし４倍であることを特徴とする請求項１０に記載の固体の半導体原料塊であることを要旨としている。

【００３０】本願請求項１２の発明では、固体の半導体原料塊は多結晶シリコンであり、種結晶は単結晶シリコンであることを特徴とする請求項７ないし１１のいずれか１項に記載の固体の半導体原料塊であることを要旨としている。

【００３１】

【発明の実施の形態】以下、本発明に係わる半導体単結晶の製造方法の一実施の形態としていわゆる原料追加方式に用いられる単結晶製造装置について添付図面に基づき説明する。

【００３２】図１に示すような本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置、例えばＣＺ法による単結晶引上げ装置１は、炉部材収納室２とこの炉部材収納室２の上方に連接して設けられた単結晶収納部３とで形成されている。炉部材収納室２にはヒータ４により加熱され黒鉛ルツボ５に内装された容器例えば石英ルツボ６が設けられており、この石英ルツボ６内で原料の種結晶本体Ｓ１が加熱溶融される。黒鉛ルツボ５は炉体７を貫通し、モータ（図示せず）に結合されて回転されるルツボ回転軸８に取り付けられている。

【００３３】また、単結晶収納部３には昇降自在に設けられたワイヤ９の下端に取り付けられた円筒形状の種結晶保持手段１０が設けられており、この種結晶保持手段１０には、種結晶Ｓが取り付けられている。

【００３４】図２および図３に拡大して示すように、種結晶保持手段１０に取り付けられた種結晶Ｓは、中実円柱形状をなす種結晶本体Ｓ１とこの種結晶本体Ｓ１の一端部に設けられた保持手段例えば円板形状の円形係止部Ｓ２とで形成されている。

【００３５】また、種結晶Ｓには固体の半導体原料塊、例えば固体で円柱形状を有する原料の多結晶シリコン塊Ｍが保持されており、この多結晶シリコン塊Ｍの一端部例えば上端部には、上記円形係止部Ｓ２が収納される中空状の収納部Ｍ１と、この収納部Ｍ１に連接し円形係止部Ｓ２と係合する係止部Ｍ２と、この係止部Ｍ２に形成された係合溝部Ｍ３が設けられている。

【００３６】なお、１１は種結晶Ｓに設けられた取付長孔Ｓ３を貫通し、種結晶Ｓを種結晶保持手段１０に保持する係合ピンである。

【００３７】上記種結晶Ｓの円形係止部Ｓ２の直径ｄ１は、種結晶本体Ｓ１の直径ｄ２の３ないし４倍であり、円形係止部Ｓ２の厚みｔ１は２０ｍｍ以上であることが好ましく、また係止部Ｍ２の厚みｔ２も２０ｍｍ以上、収納部Ｍ１の高さｈ１は５０ｍｍ以上であることが好ましい。

【００３８】従って、図４に示すように、種結晶Ｓによる多結晶シリコンＭの保持は、種結晶本体Ｓ１が係合溝部Ｍ３を貫通し、収納部Ｍ３に収納された円形係止部Ｓ２を係止部Ｍ２に係合することによって行われる。

【００３９】次に、単結晶引上げ装置１を用いた本発明に係わる半導体単結晶の製造方法の原料追加チャージ方式を説明する。

【００４０】図８は追加チャージ方式の半導体単結晶の製造工程図で、単結晶引上げ装置１の炉部材収納室２内

に設置された石英ルツボ６に小塊形状の原料の多結晶シリコンｍを充填し、さらに単結晶収納部３のワイヤ９に取り付けられた種結晶保持手段１０に種結晶Ｓを取り付け、しかる後、図４で拡大して示したように種結晶Ｓの種結晶本体Ｓ１を係合溝部Ｍ３の側部から係合溝部Ｍ３に挿入させながら円形係止部Ｓ２を収納部Ｍ３に収納させ、円形係止部Ｓ２と係止部Ｍ２とを係合させることにより、多結晶シリコン塊Ｍを種結晶Ｓおよび種結晶保持手段１０を介してワイヤ９に懸垂保持させる（図８（ａ））。

【００４１】次に、石英ルツボ６の外周に設けたヒータ４を付勢して多結晶シリコンｍを完全に加熱溶融させ、多結晶シリコン塊Ｍの溶融より先に予め石英ルツボ６の約８０％程度までシリコン融液Ｌを満させる（図８（ｂ））。さらに、小塊形状の多結晶シリコンｍとは別個に用意され、既に単結晶収納部３に収納され種結晶Ｓの円形係止部Ｓ２により保持されている多結晶シリコン塊Ｍを降下させてシリコン融液Ｌに接触させ追加溶融させる（図８（ｃ））。多結晶シリコン塊Ｍの溶融が完了するとシリコン融液Ｌは石英ルツボ６のほぼ全体に満される。

【００４２】一方、多結晶シリコン塊Ｍが溶融されて種結晶Ｓは完全に露出され、引上げ時の種結晶の機能を果たせる状態になる（図８（ｄ））。なお、多結晶シリコン塊Ｍの係止部Ｍ２が未溶融で円形係止部Ｓ２上に残存する場合には、種結晶Ｓの回転数を上げ遠心力により、係止部Ｍ２をシリコン溶融Ｌ中に落下させればよく、また多結晶シリコン塊Ｍが実質的に全部溶けて種結晶Ｓの円形係止部Ｓ２が露出されていれば、多結晶シリコン塊Ｍの一部が未溶融にまま種結晶Ｓに取り付いていてもよい。

【００４３】しかる後、単結晶引上げ装置１内を単結晶引上げ条件に適合させ、種結晶Ｓの円形係止部Ｓ２を石英ルツボ６中で溶融状態のシリコン融液Ｌに接触させて、円形係止部Ｓ２を融解したのち、種結晶Ｓに単結晶Ｉｇを成長させる（図８（ｅ））。

【００４４】さらに単結晶インゴットＩｇを成長させて引上げを完了させるが、石英ルツボ６内には再使用可能な溶融シリコンＬは残存していない（図８（ｅ））。

【００４５】上述した本発明に係わる半導体単結晶の製造方法によれば、種結晶Ｓを、本来の種結晶として用いると共に多結晶シリコン塊Ｍを保持する保持手段として用いることにより、種結晶保持手段１０とシリコン塊保持手段の交換のために、炉体８または単結晶収納部３を開放する必要がなく、多結晶シリコン塊Ｍを追加原料として溶融できて、石英ルツボ６に汚染のない十分なシリコン融液Ｌの供給が可能となり、一度に大容量のシリコン単結晶Ｉｇを高単結晶化率で引き上げることができる。

【００４６】また、単結晶引上げ装置１をゲートバルブにより炉部材収納室２と単結晶収納部３を適宜仕切るゲートバルブも不要となり、ゲートバルブの開閉に伴い単結晶収納部３から塵埃などが落下して、溶融シリコン融液Ｌが汚染されることもなくなり、単結晶Ｉｇの成長が阻害されることもなく、単結晶化率の高率化も図れる。

【００４７】さらに、引上げ工程における最初の小塊形状の多結晶シリコンｍと多結晶シリコン塊Ｍとを同時に装填する時、および引き上げられた単結晶インゴットＩｇの取り出し時以外に、一連の工程中に炉体７または単結晶収納部３を開放する必要がないため、ガス置換も不必要であり、１回の引上げに要するサイクルタイムも通常のＣＺ法よりも長くなることがない。

【００４８】次に、本発明に係わる半導体単結晶の製造方法の他の実施の形態であるいわゆるリチャージ方式を上述の単結晶引上げ装置１を用いて説明する。

【００４９】図９はリチャージ方式の半導体単結晶の製造工程を示すもので、引き上げられた単結晶Ｉｇを引上げて、石英ルツボ６に溶融シリコンＬを残存させ（図９（ａ））、次に、ゲートバルブを閉じて単結晶Ｉｇを取出すとともに、上述した実施の形態で用いた図８に示したと同様の構造を有する種結晶Ｓを種結晶保持具１０に取り付け、この種結晶Ｓの円形係止部Ｓ２に多結晶シリコン塊Ｍの係止部Ｍ１を係合させる（図９（ｂ））。しかる後、多結晶シリコン塊Ｍを降下させて、予め石英ルツボ６に収納されているシリコン融液Ｌに接触させて溶融し、シリコン融液Ｌにする（図９（ｃ））。多結晶シリコン塊Ｍの溶融によりシリコン融液Ｌは石英ルツボ６のほぼ全体に満される。

【００５０】一方、多結晶シリコン塊Ｍが溶融した後の種結晶Ｓは完全に露出され引上げ時の種結晶の機能を果たせる状態になる（図９（ｄ））。しかる後、単結晶引上げ装置１内を単結晶引上げ条件に適合させ、結晶Ｓの円形係止部Ｓ２を石英ルツボ６中で溶融状態のシリコン融液Ｌに接触させて、種結晶Ｓに単結晶Ｉｇを成長させる（図９（ｅ））。

【００５１】本実施形態の半導体単結晶の製造方法によれば、種結晶Ｓを本来の種結晶として用いると共に多結晶シリコン塊Ｍを保持する保持手段として用いることにより、種結晶保持手段１０とシリコン塊保持手段の交換のために、単結晶収納部３を開放する必要のは１回で済む。従って、シリコン単結晶Ｉｇの高単結晶化率で引き上げることが可能となり、半導体単結晶の製造コスト低減化に寄与する。

【００５２】このため、従来のリチャージ法では少なくとも２回であったゲートバルブの開閉回数を低減させ、開閉に伴う炉内への汚染のおそれを低減しつつ十分なシリコン融液の供給が可能となり、シリコン単結晶を高単結晶化率で引き上げることができる。

【００５３】

【実施例】実施例１（追加チャージ方式）

図８に記載の引上装置を用い、炉材収納室２および単結晶収納部３が大気解放状態で直径が２２インチの石英ルツボに、小形塊状の多結晶シリコンを１００ｋｇ充填した。ついでこの状態のまま単結晶収納部３に本発明の保持手段を設けた種結晶およびこの種結晶に２０ｋｇの円柱形状多結晶シリコン塊を保持させてゲートバルブを解放した状態で炉材収納室および単結晶収納部を閉じた。

【００５４】ついで石英ルツボ内の多結晶シリコンを溶融させた後、種結晶に保持させた多結晶シリコンを降下させて石英ルツボ内のシリコン融液と接触させ完全に融解した。続いて種結晶をシリコン融液に接触させ、保持手段に当たる部分を溶融せしめてから通常の方法に従ってシリコン単結晶を引き上げた。得られた無転位シリコン単結晶の収率を表１に示す。本実施形態において、ゲートバルブの開閉は行われていない。

【００５５】比較例１（追加チャージ方式）

図８に記載の引上装置を用い、炉材収納室２および単結晶収納部３が大気解放状態で直径が２２インチの石英ルツボに、小形塊状の多結晶シリコンを１００ｋｇ充填した。ついでこの状態のまま単結晶収納部３に専用の保持手段を介して円柱形状多結晶シリコン塊を保持させてゲートバルブを解放した状態で炉材収納室および単結晶収納部を閉じた。

【００５６】ついで石英ルツボ内の多結晶シリコンを溶融させたのち、専用の保持手段に保持させた多結晶シリコンを降下させて石英ルツボ内のシリコン融液と接触させ融解した。

【００５７】その後保持手段を単結晶収納部に引き上げ、ゲートバルブを閉じ、炉材収納部と隔離した後に単結晶収納部を開放して専用の保持手段を単結晶引上用のシコン種結晶に交換した。その後単結晶収納部を閉じ、内部雰囲気を炉材収納部と同一にした後にゲートバルブを開放し、種結晶を降下させて通常の方法に従ってシリコン単結晶を引き上げた。

【００５８】得られた無転位シリコン単結晶の収率を表１に示す。本比較例において、ゲートバルブの開閉は１回行われている。

【００５９】

【表１】

	実施例１	比較例１
無転位単結晶収率	１．１８	１

注１：　比較例１における無転位単結晶の収率を１としたときの比

注２：　実施例１、比較例１ともに１０回の引上の平均値

【００６０】実施例２（リチャージ方式）

図９に記載の引上装置を用い、通常の方法に従って、第１回目のシリコン単結晶を引き上げた。引き上げられた単結晶を単結晶収納部に引き上げ、ゲートバルブを閉じて取り出した。

【００６１】次に、取り出した単結晶の代りに、本発明の保持手段を設けた種結晶およびこの種結晶に５０ｋｇの円柱形状多結晶シリコン塊を保持させて単結晶収納部を閉じ、内部雰囲気を炉材収納部と同一にした後にゲートバルブを開放し、種結晶および多結晶シリコン塊を降下させて石英ルツボに残っているシリコン融液に接触させて多結晶シリコン塊を完全に融解した。その後、種結晶の保持手段に当たる部分を溶融せしめてから通常の方法に従ってシリコン単結晶を引き上げた。リチャージによって得られた無転位シリコン単結晶の収率を表２に示す。本実施例において、ゲートバルブの開閉が行われるのは１回のみであった。

【００６２】比較例２（リチャージ方式）

図９に記載の引上装置を用い、通常の方法に従って、第１回目のシリコン単結晶を引き上げた。引き上げられた単結晶を単結晶収納部に引き上げ、ゲートバルブを閉じて取り出した。

【００６３】次に、取り出した単結晶の代りに、専用の保持手段を介して５０ｋｇの円柱形状多結晶シリコン塊を保持させて単結晶収納部を閉じ、内部雰囲気を炉材収納部と同一にした後にゲートバルブを開放し、多結晶シリコン塊を降下させて石英ルツボに残っているシリコン融液に接触させて多結晶シリコン塊を融解した。その後、保持手段を単結晶収納部に引き上げ、ゲートバルブを閉じ、炉材収納部と隔離した後に単結晶収納部を開放して専用の保持手段を単結晶引上用のシリコン種結晶に交換した。その後、単結晶収納部を閉じ、内部雰囲気を炉材収納部と同一にした後にゲートバルブを開放し、種結晶を降下させて通常の方法に従ってシリコン単結晶を引き上げた。

【００６４】リチャージによって得られた無転位シリコン単結晶の収率を表２に示す。本実施例において、ゲートバルブの開閉は２回行われている。

【００６５】

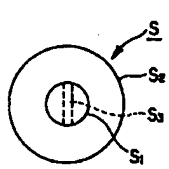
【表２】

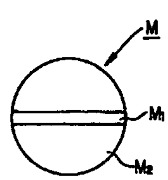
	実施例２	比較例２
無転位単結晶収率	１．０５	１

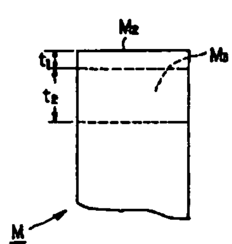
注１：　比較例２における無転位単結晶の収率を１としたときの比

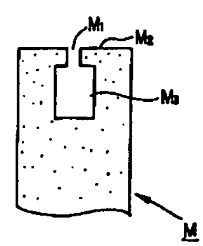
注２：　実施例２、比較例２ともに１０回の引上の平均値

【００６６】
【発明の効果】本発明に係わる半導体単結晶の製造方法によれば、種結晶を種結晶と固体の半導体原料塊を保持する保持手段として兼用することにより、これら保持手段の交換をなくして、固体の半導体原料塊による原料供給に伴う単結晶製造装置内およびシリコン融液の汚染を防止し、単結晶化率の向上を図ることができる。
【００６７】また、種結晶の兼用により、炉体またはその一部の開放をなくし、あるいは開放回数を減少させても、追加原料として固体の半導体原料塊を用いて石英ルツボに十分なシリコン融液の供給が可能となり、さらに炉内ガスの置換も不要となり、１回の引上げに要するサイクルタイムを延長させることもない。
【００６８】またさらに、原料の追加チャージ方式に適用すれば、汚染のないシリコン融液を十分に石英ルツボに供給できるので、単結晶化率の高い大容量のシリコン単結晶を引き上げることができる。
【００６９】また、原料リチャージ方式に適用すれば、汚染のないシリコン融液を繰り返し石英ルツボに供給できるので、１個の石英ルツボから単結晶化率の高いシリコン単結晶を複数本引き上げることができ、製造コストを低減できる。
【００７０】さらに、固体の半導体原料塊の保持は、この半導体原料塊に設けた係止部と種結晶に設けた保持手段とを係合させることにより行うので、種結晶を種結晶と固体の半導体原料塊を保持する保持手段として兼用が可能となり、保持手段の交換をなくして、固体の半導体原料塊による原料供給に伴う半導体原料融液の汚染を防止し、単結晶化率の向上を図ることができる。また、炉内ガスの置換も不要となり、１回の引上げに要するサイクルタイムを長くすることがない。
【００７１】さらに、種結晶に設けられた係止部を円板形状にする場合には、単結晶化率の高い半導体単結晶の引上げが可能である。
【００７２】また、種結晶の円形形状の係止部の直径を、円柱形状の種結晶の直径の３ないし４倍にする場合には、確実に固体の半導体原料塊を保持できると共に、単結晶化率の高い半導体単結晶の引上げが可能である。
【図面の簡単な説明】
【図１】本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置の概念図。
【図２】本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置に組み込まれた種結晶の側面図。
【図３】図２に示す種結晶の平面図。
【図４】本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置に組み込まれた種結晶と半導体原料塊の係合状態を示す説明図。
【図５】図４に示す半導体原料塊の平面図。
【図６】図４に示す半導体原料塊の平面図。
【図７】図４に示す半導体原料塊の断面図。
【図８】本発明に係わる半導体単結晶の製造方法の一実施形態の製造工程図。
【図９】本発明に係わる半導体単結晶の製造方法の他の実施形態の製造工程図。
【図１０】従来の半導体単結晶の製造方法に用いられる単結晶製造装置の概念図。
【図１１】従来の半導体単結晶の製造方法の製造工程図。
【図１２】従来の半導体単結晶の製造方法の他の製造工程図。
【符号の説明】
１　単結晶製造装置
２　炉部材収納室
３　単結晶収納部
４　ヒータ
５　黒鉛ルツボ
６　石英ルツボ
７　炉体
８　ルツボ回転軸
９　ワイヤ
１０　種結晶保持手段
１１　係合ピン
Ｍ　半導体原料塊（多結晶シリコン塊）
Ｍ１　収納部
Ｍ２　係止部
Ｍ３　係合溝部
Ｓ　種結晶
Ｓ１　種結晶本体
Ｓ２　保持手段（円形係止部）
Ｓ３　取付長孔

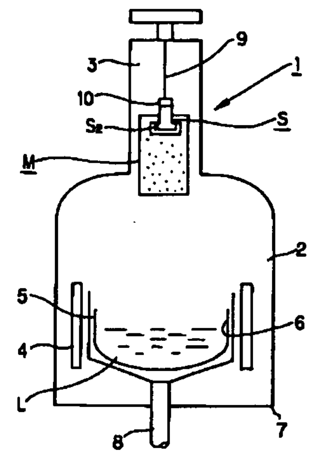
【図３】


【図５】


【図６】


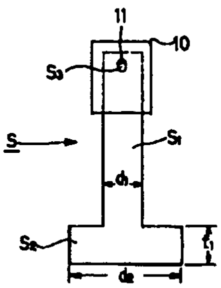
【図７】


【図1】

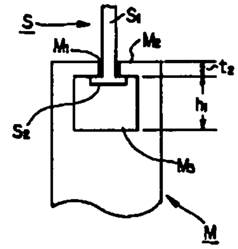


1 単結晶製造装置
2 炉部材収納室
3 単結晶収納部
4 ヒータ
6 石英ルツボ
10 種結晶保持手段
M 半導体原料塊(多結晶シリコン塊)
S 種結晶
S_2 保持手段(円形係止部)

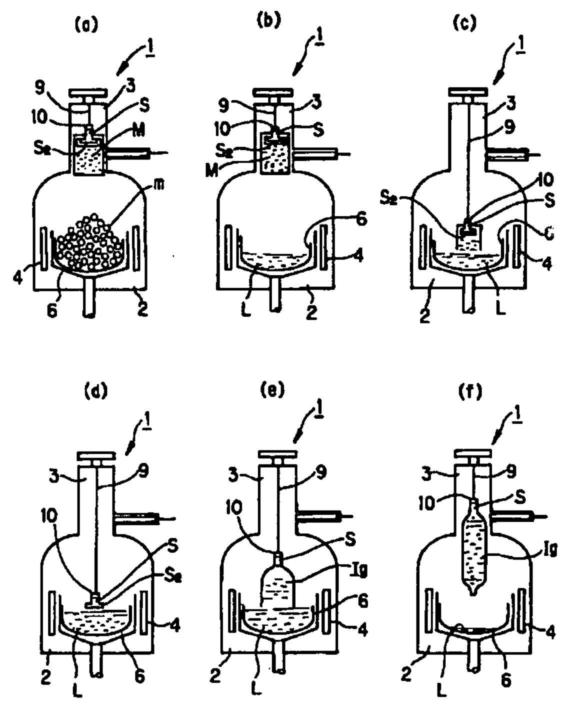
【図2】



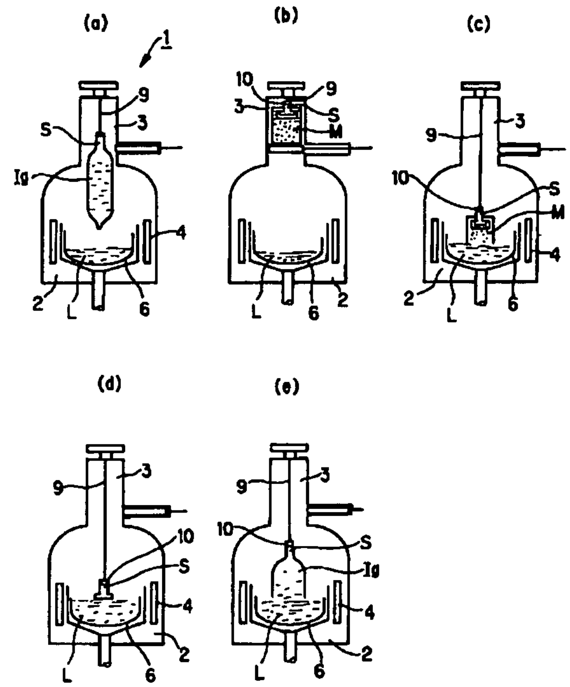
【図4】



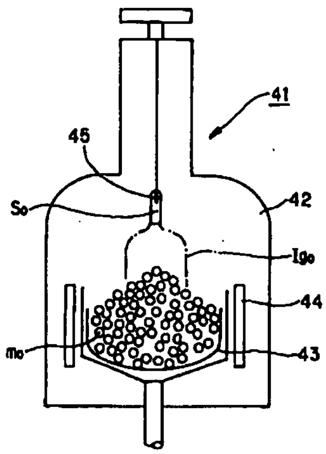
【図8】



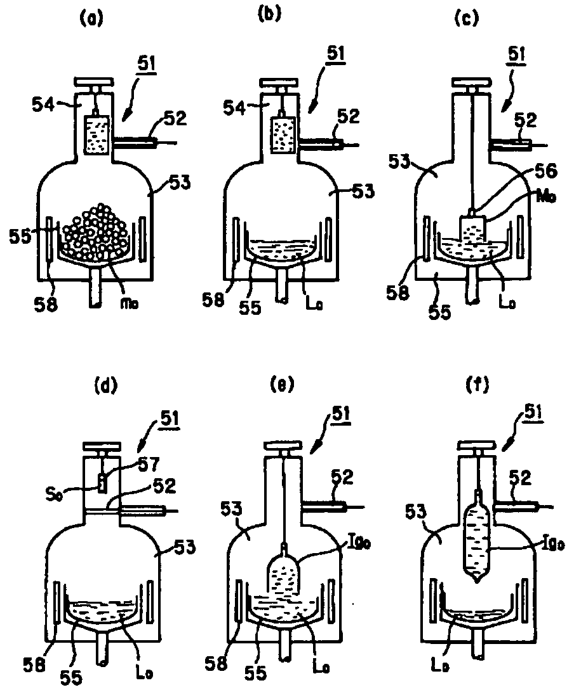
【図9】



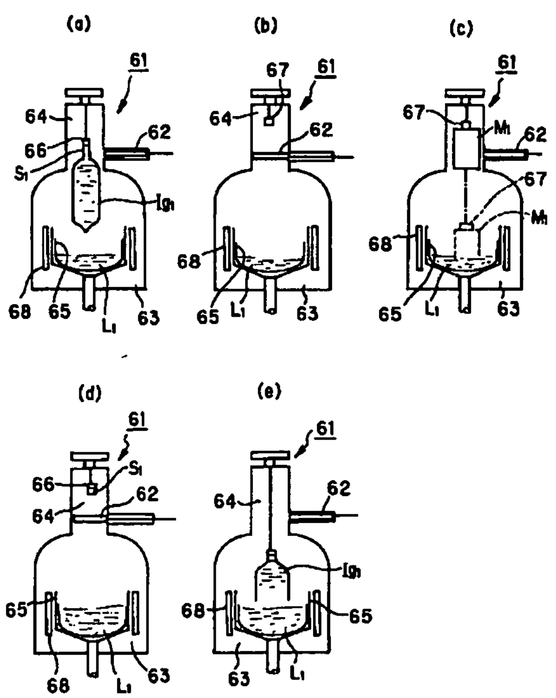
【図１０】


41
45
So
42
Igo
44
mo
43

【図１１】


(a)
(b)
(c)
51
54
52
53
55
58
mo
56
Mo
Lo
(d)
(e)
(f)
57
So
Igo

【図１２】


(a)
(b)
(c)
61
64
66
S1
62
Ig1
68
65
L1
63
67
M1
(d)
(e)

【手続補正書】
【提出日】平成１１年6月１７日（１９９９．６．１７）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】０００２
【補正方法】変更
【補正内容】
【０００２】
【従来の技術】一般に半導体ウェーハの製造方法は、多結晶半導体原料を溶融し、この原料融液に単結晶よりなる種結晶を接触させ、種結晶から半導体単結晶を成長させる半導体単結晶の製造方法が用いられている。
【手続補正２】
【補正対象書類名】明細書
【補正対象項目名】００３２
【補正方法】変更
【補正内容】
【００３２】図１に示すような本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置、例えばＣＺ法による単結晶引上げ装置１は、炉部材収納室２とこの炉部材収納室２の上方に連接して設けられた単結晶収納部３とで形成されている。炉部材収納室２にはヒータ４により加熱され黒鉛ルツボ５に内装された容器例えば石英ルツボ６が設けられており、この石英ルツボ６内で小塊形状の原料の多結晶シリコンｍが加熱溶融される。黒鉛ルツボ５は炉体７を貫通し、モータ（図示せず）に結合されて回転されるルツボ回転軸８に取り付けられている。